

Immersive Virtual Environments for University Education: Views from the Classroom

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1. Introduction

Education has long been touted as an important application area for immersive virtual environments (VEs). VEs can allow students to visualize and interact with complex three-dimensional (3D) structures, perform virtual “experiments,” view scenes with natural head and body movements, and experience environments that would be otherwise inaccessible because of distance (the surface of the Moon), scale (a complex molecule), or danger (a sunken ship). Many researchers have explored the use of VEs for education [1, 2], with some degree of success. However, few VE systems have been deployed for actual classroom use, and little is known about effective methods for employing VEs in real-world settings (the work of Johnson et al. is a notable exception [4]).

In this paper, we describe three VE applications developed to teach university students concepts in the areas of computer graphics, building structures, and computer networking, and discuss our experience in using them as integral parts of appropriate classes at Virginia Tech. We differ from Johnson et al. in our focus on post-secondary education and in our use of VEs as tools within a traditional lecture-based class. We present our observations of what worked and what did not, and offer guidelines for others wishing to incorporate VEs into the classroom.

2. Educational VE applications

In this section we describe the three VE tools developed for classroom use. All three systems use the same hardware, a portable VE system that we assembled from off-the-shelf components. We based our hardware choices on cost (educational institutions will not use VEs if they are overly expensive), robustness, and portability. The system consists of an A/V cart, a Windows 2000-based PC, a consumer-level head-mounted display (HMD), a three degree-of-freedom head tracker, a twelve-button input device, and an LCD projector.

Each system also employs a similar user interface (UI). The head tracker is used to allow natural viewing of the scene. The 12-button device (actually a chord keyboard) is used for all other input to the system, with each button mapped to a specific function. A visual aid,

which we call the interface representation (IR), shows the user which function is assigned to each button (see figure 1). Navigation is based on gaze-directed steering, and object selection and manipulation are also gaze-based, since only one tracker is available.

2.1. VENTS

The Virtual Environment Normalizing Transformation System (VENTS) is an immersive VE application intended to teach computer graphics students the multiple-step normalizing transformation for perspective views [3]. VENTS allows students to visualize a view frustum, along with related points, vectors, and coordinate systems. Users can select the various steps of the transformation, and then see these objects move to show the effect of each step. They can also freely navigate to see the transformation from different perspectives. Audio descriptions of each step are available, and users can interactively manipulate the initial conditions for the transformation.



Figure 1: *Defining a structure in Virtual-SAP*

2.2. Virtual-SAP

Virtual-SAP [5] is a VE tool for visualizing the effects of earthquakes on building structures. It is based on the structural analysis program (SAP), a finite element simulation code. Users of Virtual-SAP can build 3D structures from columns, beams, slabs, etc., and can specify their size and material properties (figure 1). The response of the structure to an earthquake is then simulated using SAP, and the results shown as a 3D animation within the VE. Users can then modify the structure if desired and try again. Pre-defined structures and asso-

ciated simulation results can also be imported directly into Virtual-SAP.

2.3. NetViz

The third educational VE is a visualization of large-scale network traffic data (NetViz). This tool is intended to help students visualize an abstract, multi-parameter dataset (traces or real-time data from backbone-level network traffic). NetViz uses a “city” metaphor to represent the data, with buildings representing a connection or set of connections. The city is divided into “districts” representing different protocols. A building’s north-south position represents the connection’s average bandwidth, the east-west position represents its average packet size, and the height represents its lifetime. Users can watch the landscape change, navigate freely in 3D, and for buildings that represent multiple connections, can “enter” the building to see the data for each individual connection displayed in a sub-visualization.

3. Classroom usage

We used the three VE applications as teaching tools in undergraduate computer graphics, building structures, and networking classes at Virginia Tech. These classes contained approximately 70 students total. In each of the classes, we provided a brief training session on the use of the hardware and the application, then used the VE in combination with other teaching methods. Only one student at a time could use the HMD, but the rest of the students saw the same view projected on a large screen. More information on the various teaching methods we employed is given below.

We also observed and assessed the effectiveness and usability of the VE applications in the classroom. We used multiple observers, student surveys, student and instructor interviews, and written tests for assessment.

4. Observations and lessons learned

Although analysis of our quantitative results is ongoing, here we present some general observations, issues, and guidelines gleaned from this research.

4.1. Advantages of VEs for education

Our experiences showed that interactive VEs could allow instructors and students to try various “what-if” scenarios that would not be possible with static animations. We also found that students were more involved and engaged with VEs than during normal classroom activities, which may lead to better learning or retention. Finally, we saw evidence that 3D visualization was the only way to effectively communicate certain information (e.g. the characteristic pattern of FTP traffic). It is not clear from our work so far, however, how important immersion is to educational VE applications.

4.2. Integrating VEs into the classroom

We noted four different ways that instructors can use VEs in their classrooms. In the *sequential* approach, instructors give a standard lecture, and then use the VE to reinforce the lecture concepts. The *integration* approach consists of VE use during the course of a lecture. Instructors can also keep the VE system in the classroom and use it during multiple class periods – this is the *multiple-use* approach. Finally, in the *special topics* approach, instructors dedicate a period to the use of the VE, and do not connect it to the rest of the course. In our experience, both the sequential and integration approaches have worked well, but integration has the advantage of allowing students to form immediate links between the lecture material and the VE.

We also found that having one student control the VE by wearing the HMD while the rest of the class sees her view on a large screen was effective and understandable. Students could easily correlate the user’s head movements to the changing graphics, and could thus understand the 3D structure of the scene.

4.3. User interface design

We observed that instructors wanted the students to obtain certain important views of the scene (e.g. a top-down view of a building). Thus, UI designers should provide easy ways for students to obtain these views, and perhaps methods to “lock” these views so that students do not need to hold their heads in a given position for long periods of time.

4.4. Other observations

Our experience has led to the recognition of many other significant issues and the formulation of other guidelines related to student and instructor use of VEs, technology, and assessment of VE effectiveness, which will be included in the full-length version of this submission.

References

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